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Knowledge Management in Lean Production Systems

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Abstract

The implementation of Lean Production Systems is more than redesigning some production processes. The most seminal change has to be made in people's knowledge. Otherwise, the changes will not be sustainable. Most implementation processes describe the sequence of necessary tasks but do not regard the integration of knowledge in the organization. Therefore, it is necessary to analyze how knowledge and knowledge flows can be described. The research showed that a multitude of different knowledge flows can occur during the implementation of Lean Production Systems and that a decentralized, role-specific approach can help to identify adequate methods of knowledge management.

Keywords: Lean production; Knowledge management; Lean implementation

1. Introduction

Manufacturing enterprises are in an intensive competition in order to offer products with the best quality to reasonable costs and with a minimal lead time. Countless benchmarks are conducted by consulting firms and scientific facilities. Probably the most recognized benchmark was the International Motor Vehicle Program (IMVP) that was conducted by the Massachusetts Institute of Technology in the 1980s. The research revealed the superiority of Japanese manufacturing enterprises, especially Toyota. Furthermore, the authors described the basic principles of the so-called lean management. [1], [2] At the same time, the former Toyota engineer and founder of the Toyota Production System (TPS) Taiichi Ohno published his experiences from developing and improving processes at Toyota. [3] Thereby, the theoretical fundamentals of lean should have been widely spread.

Western enterprises started to implement some of the identified principles but did not achieve the expected results. It took years to find out that they had implemented isolated principles but failed to implement an integrated system. Lean implementation turned out to be more than a common improvement project. Manufacturing enterprises then tried to implement holistic Lean Production Systems in order to achieve more sustainable results. Nevertheless, most LPS implementations still fall short of the expectations. Several authors identified that many companies focus on the visible elements of LPS like methods and tools and tend to change the layouts and processes of their production. However, the critical factors for the sustainable success of production systems are generally rather people-related than technology-related. [4], [5]

Five root causes for common barriers have been identified, that have to be adapted to the specific requirements of LPS implementation: Leadership, organizational culture, planning, organizational structure and LPS knowledge. [6] This paper focuses on the two aspects organizational structure and LPS knowledge. The field of implementation has already been focused by several authors [6], [5], [8], [9], [10] and their findings will be described in the next chapter. Based on these findings, approaches for the organizational structure and the knowledge management in LPS are shown. Both have a strong interrelation because knowledge has to be

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transferred between different roles in the organization. These roles depend on the specific organizational structure of the LPS implementation. The other two root causes, organizational culture and leadership, also have strong interrelations and are subject of other research activities. [11], [12]

2. Implementation of Lean Production Systems

2.1. Implementation process

The transition to lean might be one of the most challenging changes manufacturing enterprises are facing these days. The implementation of a Lean Production System marks a fundamental transition of the enterprise's principles, methods and tools. This change affects each employee in every position. [5]

In the following, the implementation process according to [6] and [8] will be explained. It names four major phases of implementation. The process starts with centrally controlled tasks in the first phase but is more decentralized with every phase. The initial step of the process describes the awareness of management that an LPS would contribute to the enterprise's long-term and sustainable development. The second step is the lean assessment and strategic planning. The whole enterprise with its stakeholders, strategic objectives as well as the business processes and methods are analyzed. In the conceptual design of the Lean Production System, a central steering committee is installed in order to monitor and control the implementation process. The last step of the basic planning phase deals with the master planning of LPS implementation.

The second phase is already rather decentralized and begins with organizational changes regarding the LPS implementation. After the central organizational structures have been installed in the first phase, the local structure follows in this step. The sixth step deals with the detailed planning of implementation. The detailed plans are necessary to consider local conditions.

The third phase is completely decentralized and takes place in the departments of the enterprise. Often, the phase starts with a pilot implementation. Based on these important experiences, the entire LPS rollout starts. At the beginning, the rollout is often supported by central staff units and external LPS experts but it should successively get more and more decentralized. The responsibility for process improvement should be slowly delegated to the shop floor level.

The last phase of LPS implementation is the daily operation and continuous improvement. This ongoing phase includes the maintenance and the continuous improvement of the designed processes. In this last step, improvement activities should be delegated to the shop floor level. Of course, management still has to foster change and innovative concepts but the daily improvement should be carried out on the shop floor.

2.2. Knowledge in LPS implementation

Moving physical parts in production like materials, machines and work places is only the visible part of LPS implementation. Many enterprises fail to implement their Lean Production System sustainably because they see their shop floor as a pure technical system. This perception is caused by a tayloristic imprint, which many enterprises still have. [15] In Taylor's scientific management, knowledge and labor was strictly separated. Workers were obligated to execute the processes that management had designed. In such a system, the decentralized and worker-based continuous improvement cannot work out. In order to implement an LPS successfully, this separation has to be discarded. A sustainable adaption in daily operations can only be achieved, when the information about principles, methods and tools of the LPS is deeply understood in all relevant areas, especially by all shop floor workers.

An LPS implementation implicates the distribution of information and thereby the identification, acquisition, development, transfer, application and preservation of knowledge. Therefore, the provision of knowledge is crucial in LPS implementation but most implementation processes lack a systematic description of the flow of knowledge during implementation. [16]

Due to the special importance of knowledge in sustainable LPS implementation, the following chapter deals with the basics on knowledge management.

3. Knowledge Management

3.1. Terms and definitions

Davenport defines knowledge as "a fluid mixture of framed experience, values, contextual information, and expert insight that provides a framework for evaluating and incorporating new experiences and information". In addition, Davenport states that knowledge belongs to the knower, whereas in a company, knowledge can be embedded in documents as well as in the organization. [17]

From this definition can be derived, that knowledge depends on the person who owns it. Moreover, knowledge can either be written down as well as implemented in the organizational structure. Gensicke defines knowledge as "based on information that is interpreted in the context of the recipient's experiences and expectations. Knowledge is a prerequisite for purposeful action". [18]

Consequently, for structuring and organizing the knowledge of an enterprise, it is important to implement

knowledge management. According to Nonaka, knowledge management is defined as "the process of continuously creating new knowledge, disseminating it widely through the organization, and embodying it quickly in new products/services, technologies and systems". [19] Hence, knowledge management is a process that creates, disseminates and embodies knowledge. Knowledge management can be organized either centralized or decentralized. [17]

3.2. Approaches to knowledge management

An understanding of the **transformation of knowledge** is crucial to understand knowledge flows. Therefore, Nonaka classifies knowledge in tacit and explicit knowledge. [19] Explicit knowledge can be verbally framed, written down and stored. The person, who possesses the explicit knowledge, knows about it and can communicate it. Thereby, it is easy to transfer explicit knowledge and to use it in data processing. In contrast, tacit knowledge is complicated to formulate and transfer. It is based on personal attitudes and experiences of the knowing person and is expressed by the person's belief and behavior. [19], [20] However, technical skills and LPS knowledge can also be tacit because the person possessing it might not know about it or is not able to formulate it. Nonaka names four possibilities to transform knowledge from one type to the other. Tacit knowledge can be transformed into explicit knowledge by externalization. For example, in lessons learned the tacit knowledge that has been gained in form of experiences and impressions is written down and thereby externalized. A different way to transfer it to another person is the socialization, whereby tacit knowledge transfers to the other person without transforming it. Socialization can happen without specifying the knowledge by language. For example, children are learning from their parents by imitating their behavior. In order to transfer explicit knowledge, it can either be internalized or combined. Internalization occurs, when the explicit knowledge is applied over and over and the person includes it in habits and daily routines. Combination is the process, when new knowledge is gained by integrating isolated explicit knowledge in a holistic system.

In cooperation with several enterprises, Probst developed an approach of **knowledge management functions** that describe the key processes of knowledge management. [21] The six operative functions are identification, acquisition, development, transfer, application and preservation. They are arranged in a loop, which describes the general direction and sequence but allows other paths, too. The strategic functions are the definition of the knowledge management objectives and the evaluation of results after a full loop. The described functions can be classified in three different dimensions: projects, leadership and processes. The three dimensions allow a very precise description and structuring of knowledge management activities. [20]

The introduced approaches describe how knowledge is transferred and how the knowledge management process is designed. The following two approaches focus on how the person perceives the knowledge management and which barriers might occur.

The **knowledge management portfolio** includes four different fields in which knowledge management activities can be classified from the users' point of view. For the person who has to conduct the activity, it is important to know, whether knowledge management is mandatory or optional and whether the activity is rather formal or creative. [20]

Knowing the possible **knowledge barriers** that might occur affects the way knowledge is managed. [23] When transferring knowledge from one person to another, individual or collective barriers are possible. Furthermore, the barriers could either be caused by structural or cultural reasons. These four different types of barriers lead to another four possible combinations.

4. Knowledge Flows in LPS Implementation

In today's information age, enterprises have access to a vast amount of information and knowledge concerning the implementation of a Lean Production System. Due to the complexity of the lean transition, most enterprises hire consultants to support and train their employees. [6] The crucial part of knowledge management in implementation is not to get the knowledge, but to incorporate it in the whole organization. For describing this particular process, the term of knowledge flow is explained and the relevant roles are introduced.

4.1. Knowledge flows

The flow of knowledge is usually invisible and can occur intended or unintended. [24] It can be described as "the passing of knowledge between nodes…". [25] A node can be a member of a team or a role. [25] In the following, the term role will be preferred, because roles are an important part of LPS implementation. The use of roles in the implementation process allows describing knowledge flows, responsibilities and tasks without knowing the actual person.

Knowledge flows start and end at roles that operate as sender and receiver. The description of such a knowledge flow should contain three crucial attributes: direction, content and roles (sender and receiver). [24]

Fig. 1 depicts the general structure of knowledge flows and an exemplary description. It shows that a knowledge flow is initiated by the sender and has to be

integrated by the receiver. These steps could be specified using the characteristics introduced in the last chapter.

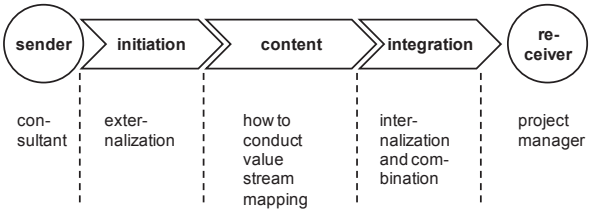

Fig. 1. Example for the structure of knowledge flows in LPS implementation [25], [26]

With the increasing level of detail, the knowledge flow gets more adapted to the specific situation. The description with the knowledge barriers or portfolios depends on the subjective perception of the person that fulfills the respective role. [24] Thereby, the depiction of one particular knowledge flow gets more detailed but the significance for the implementation in general in form of a reference model decreases. This relation can be described with the entropy in information theory, which is based on the Shannon entropy. [27] From this approach can be interpreted, that the information contained in a message decreases with the increase of the portion that is determined. Applied on knowledge flows can be derived, that with an increasing description of an ideal knowledge flow (level of detail) the probability of actually finding such a knowledge flow decreases (probability of occurrence). This detailing dilemma of knowledge flows is shown in Fig. 2.

The analysis of different LPS implementations has shown that knowledge flows differ widely. The affected roles are on the lowest level of detail, they still cannot be generalized but most enterprises have similar roles, which will be described below. The way of knowledge transformation shows some trends in some steps of implementation but cannot be generalized. Other more specific descriptions of the knowledge flow significantly increase the level of detail but fail any attempt of generalization.

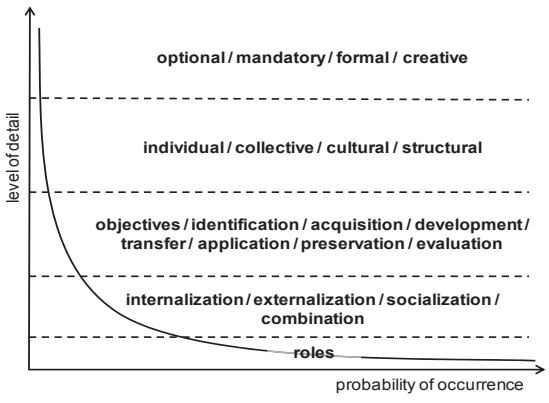

Fig. 2. Detailing dilemma of knowledge flows

They depict one possible knowledge flow out of almost infinite possibilities. For this reason, knowledge flows in LPS implementation can just be described with the conventional sender-receiver model. Therefore, the different roles in LPS implementation will be introduced in the next chapter.

4.2. Different roles in LPS implementation

Roles are the nodes in knowledge flows. They are not bound to a specific person [28] and can be described by their tasks, responsibilities and their authority concerning decisions [29]. Roles are common in the description of project management organization but are not described for the implementation of Lean Production Systems. In order to identify the relevant roles in LPS implementation, roles from project management literature were analyzed and a set of roles was determined that fits LPS implementation. Therefore, the described roles in [28], [30], [31], [32] were compared and the roles top management, steering committee, project manager, shop floor management and employee were derived. The description of LPS implementation shows that LPS experts are necessary. These roles were matched with the known tasks, responsibilities and authorities from LPS implementation processes in [6], [5], [8], [9], [10], [33]. In doing so, detailed role descriptions could be elaborated. The research showed that the role of the LPS expert is a key node in the implementation and depending on the organizational structure of the implementation, even different types of LPS experts might exist.

In LPS implementation, the general line organization is supported by LPS specific structures. According to [10] and [11], four different organizational structures can be described: Self-controlled (no additional structure), Staff unit, LPS-Department, Champions

In each of the four approaches, the general line organization persists. In most enterprises, a combination of these structures exists. Generally, they can be classified by external and internal as well as centralized and decentralized structures. In most implementations, external LPS consultants support the process usually at the rather centralized steps of implementation. Internal LPS experts could be a staff unit, an LPS department or an LPS champion. The staff unit controls the process in the centralized steps and helps the decentralized LPS champions to manage the daily implementation tasks on shop floor level. An LPS department can be either centralized only or have centralized and decentralized elements. Most LPS departments can be found in large enterprises, which need many LPS experts. Another possible way is the self-controlled implementation. In this case, the implementation process is carried out

without additional organizational structures. This can only be recommended for very small enterprises.

The identified roles in LPS implementation represent the necessary input for a systematic approach to match methods regarding the specific situation. [16] This approach will be introduced in the next chapter.

5. Decentralized knowledge management in LPS

The challenge in supporting LPS implementation with knowledge management lies in the multitude of possible knowledge flows. The centralized knowledge flows in the first steps of implementation are not crucial because they are usually controlled and assisted by management and external LPS consultants. Furthermore, in the first steps of implementation the affected roles have a low number of persons. In later, more decentralized steps, especially the role "employee" will be adopted by many different persons, which increases the complexity in knowledge flows. Due to that, a general determination in form of a reference model is not possible yet and another approach has to be chosen. Decentralized knowledge management does not need determined knowledge flows. Instead, the knowledge flow is individually supported in each case. Therefore, a generic knowledge management tool can be applied that identifies the adequate method for the particular situation taking into account the role and the personal perceptions of the situation. [20] The tool has three modules, which will be described in the following.

5.1. Knowledge flow analysis

The goal of this module is to describe the requirements of knowledge management in the specific situation. Therefore, an intuitive requirements assessment is conducted.

It has to be regarded that in decentralized knowledge management the user might not have any knowledge concerning the introduced approaches like knowledge transformation, functions, barriers or portfolios. The required information has to be gathered without explicit explanations. Therefore, the user has to answer a questionnaire in which the knowledge management approaches are imbedded. At first, the respective role has to be chosen. The role has an extraordinary impact on the adequate method. Then, role-specific questions have to be answered that describe the preconditions for the different forms of knowledge flow characterization. The questionnaire is used to create a demand pattern, which describes the requirements concerning knowledge management in the specific situation and milieu. The demand pattern is a 36-field matrix which combines the four introduced knowledge management approaches.

5.2. Method catalog

The demand pattern will be matched with a method catalog. Therefore, a multitude of knowledge management methods have to be described in detail and then characterized with a similar pattern. After matching the methods, a standardized description supports the person who wants to use the method. At first, the objective and user group of the method is given. The user can double-check if the method matching did result in an adequate method. With the detailed explanation, the user can learn how to apply the method. It is complemented by examples and advises as well as by information about usual duration and common problems of the method. [20]

5.3. Method matching

Using the demand pattern and the method catalog, the matching of actual demand and available methods can be conducted. For this, each field of the demand pattern has to be rated concerning its relevance for the particular knowledge flow. The rating is derived from the questionnaire, in which the user has to select the best fitting answering possibility. For example, an employee is asked how cooperative his colleagues are. Possible answers vary from "not at all" to "very much". Each answer is linked to a specific rating and refers to a field of the pattern. Every method from the catalog has been rated in the same way.

The method matching module calculates the overall-rating for each method. Therefore, each field of the demand pattern is multiplied by the respective field in the method pattern. The results for each field are summed and describe the overall-rating. As result of the method matching the seven knowledge management methods with the highest overall-rating are chosen.

All three modules are realized in a software prototype, which guides the user to the adequate method. The user interacts with the software interface, without having any specific knowledge about the methods or knowledge flows in general. At the beginning of the matching, the user has to choose one of the predefined roles, all other information concerning his demand is gathered by the computer-based questionnaire. After having answered all questions, the user receives a list of knowledge management methods that could support his respective knowledge flow.

6. Summary

Knowledge is an essential part in the implementation of Lean Production Systems. However, recent implementation processes focus on the sequence of tasks but do not describe the process of integrating the

relevant knowledge in the organization. This paper described the implementation process of LPS and possible forms to classify knowledge. It has been concluded that the development of a detailed reference model of knowledge flows is not possible so far because LPS implementation offers too many possible knowledge flows. The analysis of several actual implementations showed that the roles in implementation could be generalized as a basis for specific descriptions and further research. With the roles in LPS implementation, a method could be used, which allows to identify adequate methods for single knowledge flows. At the moment, this seems to be the best suited approach for supporting knowledge management in LPS implementation. Future research should try to find structures in knowledge flows that can be generalized in form of a reference model.

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